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EFFECTS OF GOVERNMENT POLICY ON
AGRICULTURE: AN EMPIRICAL ANALYSIS

R. McFALL LAMM
National Economics Division
Economics, Statistics, and Cooperatives Ser
U.S. Department of Agriculture
Washington, D.C. 20250

STAFF REPORT

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UNITED
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DEPARTMENT OF
AGRICULTURE

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R. McFall Lamm, Jr., National Economics Division; Economics, Statistics, and Cooperatives Service; U.S. Department of Agriculture, Washington, D.C. 20250.

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ABSTRACT

Most empirical efforts to evaluate the effects of government policies on agriculture have considered policies applied to specific commodity sectors. The results have been the construction of a number of highly specialized sector models which ignore cross-sector policy effects. This paper presents the results of an attempt to construct an aggregate model of agriculture which considers jointly all major agricultural policies implemented over the last 3 decades.

The results indicate that government intervention in agriculture generally reduced farm income and production below what it would have been; lead to lower food prices, benefitting consumers; and constrained capital for labor substitution. Government programs did lead to greater price stability, however, which was a basic objective of agricultural programs.

Key words: Agriculture policy, farm programs, price support, land diversion, food stamp program, dairy price support program;

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1. Introduction

Most empirical attempts to evaluate the effects of government policies on agriculture have generally concentrated on policies applied to specific sectors. This has resulted in the construction of highly specialized simultaneous equation sector models. Recent efforts include Heien's (13,14) models of the pork and dairy sectors; Freebairn and Rausser's (6) meat sector model; Salathe, Dobson, and Peterson's (25) dairy sector model; Houck, Ryan, and Subotnik's (16) soybean model; Arzac and Wilkinson's (1) feed grains and livestock model; and Lamm's (17) peanut sector model. These models, while broadly based and quite large in some cases, ignore cross-sector policy effects, however.

An integrated cross-sector approach allows a response to several broad and significant questions which specialized sector models can deal with only on a limited basis. For example, what are the effects of major government programs on investment, employment, and land utilization in agriculture? What are the effects of government policy on agricultural product prices, consumption, and production? How do demand side policies, such as the food stamp program and domestic food donations programs affect resource utilization and prices?

The objective of this paper is to respond to these issues and other substantive policy questions raised in recent years using a rigorously

derived, cross-sector econometric model of agriculture. In this respect, the empirical approach normally followed in the construction of sector agricultural models is extended to agriculture as a whole. The estimated model is relatively small—the assumption is that a large model is not necessary to represent the basic structure of the food and fiber system. Four product makets and 3 resource markets are represented by 15 simultaneous equations. The construction of the model departs from traditional procedures used by agricultural economists in that the model is highly aggregated, in that the reduced form of the model is estimated instead of the structural equations, and in that a series of tests are carried out to determine whether causality is properly represented in the model.

2. An Overview of the Approach

A virtue of aggregation is that it drastically reduces the number of variables and equations necessary to represent a system and allows for generalizations about system behavior which are usually not possible from disaggregated models. Most important, aggregation allows difficult analytical problems to be made manageable. This view is expressed in early work by Tobin (35), and Girshek and Haavelmo (9) in attempts to model the food sector. There are costs involved, however, in that aggregation sometimes obscures microeconomic decision dynamics.

The model utilized in this study is based on a theoretical representation in which consumers of agricultural products maximize utility in a 2-step procedure. In the first step, consumers determine expenditure levels for broad classes of goods, including food. In the second step, consumers select the quantities of different foods they desire subject to

expenditure constraints, food stamp availability, and food donations through federal distribution programs. Optimization yields a family of general demand functions.[1]

Producers of agricultural products maximize profit in a 2-step procedure. In the first step, expected profit is maximized by selecting provisional time paths for output and input levels, given expected prices and an intertemporal production function. This is the long-run planning problem. In the second step, producers maximize current profit by selecting output and input levels given actual prices, short-run production constraints, fixed factors, and governmentally imposed constraints on prices and resource use. Optimization yields general supply and derived demand functions. Combining the market versions of these equations with the appropriate demand functions and market equilibrium identities results in a simultaneous equation representation of the agricultural system.

Recent approaches to specifying empirical systems of demand equations have relied on the application of theoretical contraints to obtain estimates of system parameters (George and King (8), for example) or the assumption of explicit functional forms for utility functions which yield estimateable forms for demand functions. Both of these approaches are rejected in this study--the former because it imposes static constraints on what might be a dynamic problem, and the latter because it requires the analyst to know the functional form of the utility function.

On the supply side, recent work has concentrated on the estimation of general forms of profit, cost, and production functions jointly as part of system of cost or revenue share equations (see Griffen (12) and Weaver (36), for example). These approaches generally consider only the short-run

decision problem, disregard simultaneity with the demand side, and require a more complicated estimation procedure, while focusing on structural equation estimation.

As an alternative to estimating the structural equations of the model developed in this study, the unconstrained reduced form is estimated. The advantages of this approach are that (1) it does not require the prior specification of structural functional forms and constraints--this reduces the possibility of bias in the reduced form since the structural specification of the model acts as a system of constraints when the reduced form is derived; (2) it simplifies implementation of causality tests since causality is hypothesized as unidirectional in the reduced form; and (3) it simplifies estimation, the analysis of the dynamic properties of the model, and the performance of policy simulation experiments.

3. The Theoretical Framework

In the first step of the consumer decision problem, individuals maximize intertemporal utility subject to expected income. This leads to a consumption plan with an expected path for expenditures by broad expenditure categories (food, housing, apparel, for example). Friedman (7), Modigliani and Brumberg (20), and George and King have described the way the process works explicitly.

In the second step, consumers maximize myopic utility given prices, under the assumption that planned expenditures are not revised and that individual utility functions are additive by expenditure category. Governmental activity in food markets complicates what might otherwise be a simple decision problem, however. Consumers may receive food under government donations programs or food stamps as a part of low-income

assistance. In addition, habit formation and nutrient requirements play an important role in the food consumption decision process.

Incorporating these aspects into the problem formulation, the second-step decision is written as

(1) $\max_{q_t} \theta(q_t) \; \forall t$ subject to

(2) $q_t = h_t + f_t \quad \forall t$

(3) $m_t + w_t = p_t h_t \quad \forall t$

(4) $q_t = \phi(q_{t-1}) \quad \forall t$

where $\theta(\ldots)$ is a continuous ordinal utility function, q_t is a vector of food quantities consumed in period t, h_t is a vector of food quantities purchased, f_t is a vector of food quantities donated under government programs, m_t is total food expenditure, p_t is a vector of prices corresponding to the foods represented in the q_t vector, w_t is food stamp payments, and $\phi(\ldots)$ is an ordinal function representing habit formation.

Constraint (2) requires that consumption equal the sum of purchased and donated quantities. Constraint (3) requires the sum of food expenditures and the value of food stamp donations to equal the value of consumption. A general solution to the problem yields demand functions of the form

(5) $q^*_{it} = \psi_i(p_t, f_t, m_t, w_t, q_{t-1}) \quad i=1,\ldots,I_1 \quad \forall t$

where * denotes the optimizing value. This is a discrete dynamic function as long as $dq_{it}/dq_{i,t-1} \neq 0$. The government controls food consumption partially through f_t and w_t.

The 2-step producer decision problem is similar to the 2-step consumer decision problem. In the first step, producers solve their planning

problem: intertemporal profit is maximized subject to an intertemporal multiple-input, multiple-output production function given expected prices. The solution to this problem results in long-run supply and derived demand functions with quantities functionally dependent on all expected input and output prices over the planning horizon.

Under the assumption that producers resolve their planning problem in each period, in period t the optimal input level in the next period is

$$(6)\quad s^*_{n,t+1} = \rho_n[E(p_{t+1}),\ldots, E(p_{t+T});\ E(r_{t+1}),\ldots, E(r_T)] \quad n=1,\ldots,N \quad \forall t$$

where $s^*_{n,t+1}$ is the optimal input level for the nth input, E(...) is an expectations operator, p_t is a vector of output prices, r_t is a vector of input prices, and T is the number of periods in the firms planning horizon. When period t+1 arrives the level of the nth input has already been determined. If this level cannot be adjusted, then actual input equals planned input and the nth input is said to be fixed.

In the second step of the decision problem, producers maximize profit in the current period given actual prices, fixed inputs, the short-run production function, and governmentally imposed constraints. This problem is stated as

$$(7)\quad \max_{z_t, v_t} p_t' z_t - r_t'(v_t + s_t^*) \quad \forall t \text{ subject to}$$

$$(8)\quad u_t = v_t + s_t^* \quad \forall t$$

$$(9)\quad \gamma(z_t, u_t) = 0 \quad \forall t$$

$$(10)\quad u_t \leq 1_t \quad \forall t$$

$$(11)\quad z_t,\ v_t,\ u_t \geq 0 \quad \forall t$$

where z_t is a vector of output levels, v_t is a vector of variable input

levels, u_t is a vector of total inputs, s_t^* is a vector of planned input levels which cannot be adjusted, p_t is a vector of output prices, r_t is a vector of input prices, and l_t is a vector of governmentally imposed restrictions on input utilization (such as acreage allotments or diversions). Relation (8) states that input utilization equals the sum of planned utilization and adjustments; relation (9) is Lucas' (19) short-run production function; relation (10) is a government control constraint; and relation (11) imposes nonnegativity on quantity variables.

The second-step producer decision problem allows a direct role for input fixity through the short-run production function. If the level of the nth input is completely fixed in period t then $u_{nt} = s^*_{nt}$ and no adjustment is possible. This would be the case if the nth input was plant size. On the other hand, if the level of the nth input is compeltely variable in t, the $u_{nt} = v_{nt}$. This would be the case with a highly variable input like labor.

Satisfaction of the Kuhn-Tucker conditions for an optimum implies short-run supply and variable derived demand functions of the form

$$(12)\quad z_i^* = \tau_i(p_t,\ r_t,\ l_t,\ s^*_t) \qquad i=1,\ldots,I\ \forall t$$

$$(13)\quad v^*_k = \delta_k(p_t,\ r_t,\ l_t,\ s_t^*) \qquad k=1,\ldots,K\ \forall t.$$

Alternatively, total derived demand functions can be expressed as

$$(14)\quad u_k^* = \alpha_k(p_t,\ r_t,\ l_t,\ s_t^*)$$

Substitution of the decision rule for the level of s^*_t (given in equation (6)) gives long-run supply and derived demand functions:

$$(15)\quad z_i^* = \tau_i(p_t,\ r_t,\ l_t,\ E(p_t),\ldots,E(p_{t+T-1}),\ E(r_t),\ldots,$$
$$E(r_{t+T-1})\ ) \quad i=1,\ldots,I_2\ \ I_2 \leq I_1\ \ \forall t$$

(16) $u_k^* = \alpha_k(p_t, r_t, 1_t, E(p_t),\ldots, E(p_{t+T-1}), E(r_t),\ldots,$
$E(r_{t+T-1}))\quad k=1,\ldots,K \;\forall t$

In the market, consumer behavior is characterized by I market demand functions for agricultural products. Firm behavior is characterized by I market supply functions, and K derived demand functions. To assure that equilibrium obtains, that all markets clear, consumption must equal production less net product outflows. This imples

(17) $q_{it} = z_{it} + b_{it} + g_{it} \quad i=1,\ldots,I \;\forall t$

where q_{it} is now defined as aggregate consumption of the ith agricultural product, z_{it} is aggregate production, b_{it} is change in stocks less net exports, and q_{it} is change in government stocks.

Assuming instantaneous adjustment and perfect aggregation, relations (5), (15), (16), and (17) represent a simultaneous structural model of agriculture. Included are I demand functions, I supply functions, I market equilibruim identities, and K derived demand functions: 3I+K equations. There are 3I+K endogenous variables: q_{it}, z_{it}, p_{it}, and u_{kt}. Resource prices are determined exogenously since agricultural producers must compete with nonagricultural producers in capital, land, and labor markets.

The model is basically a competitive process representation—individual decision makers regard prices as fixed. Governmental activity plays an explicit role in the determination of consumption, production, prices, and input utilization, however. On the demand side, the food stamp program and domestic donations programs influence consumption directly. On the supply side, changes in diversion programs determine production and input utilization levels.

The effects of the price support program are not reflected in individual decisions directly, but through the market equilibruim identity. Consequently, government purchases or sales of agricultural products has indirect effects on consumption, production, prices, and input utilization through the reduced form of the model. As long as government stocks remain constant or decline due to government sales of agricultural products, market prices are above support levels. When agricultural products are purchased by the government, prices are supported. Hence, price support is represented in the model through the government stocks variable.

4. Empirical Implementation

The estimation of the long run version of the model requires that the expectations formation process be explicitly specified. This is an important aspect of model specification since system behavior is conditioned on the expectations structure. In this study, expectations are assumed to be formed rationally. This assumption applies both to the formation of current period expectations and future period expectations as well.

Three assumptions underly the expectations formations process embodied in the model. These are (1) that expected prices are realizations of stationary stochastic processes, (2) that decision-makers understand the covariance structure of these processes sufficiently well to form least squares forecasts, and (3) that these forecasts represent expected prices and are introduced in the model under the assumption of perfect foresight. These assumptions form a basis for the implementation of expectations formation processes as described by Nerlove (22), Sims (32), and others.

Theoretically, decision-makers consider the history of all system variables dated prior to the current period in formulating a current period expectation. The inclusion of multiple distributed lags to represent this process is analogous to the construction of a relatively complex forecasting model, however. In agriculture, decision-makers are not likely to digest the large amounts of information necessary to construct complex forecasting models, but respond to recent price history as a primary influence. For this reason, and because prices convey large amounts of information about the system state, expectations formation is assumed dependent solely on past real prices. This type of process, although simplistic, allows decision-makers to recognize cyclical variations in real prices and implies that decision makers are not subject to money illusion.

Explicitly, expectations formations in the model are assumed to be generated by the processes:

$$(18)\quad E(p_t) = \sum_{j \geq 0} A_j p_{t-j} \quad \forall t$$

$$(19)\quad E(r_t) = \sum_{j \geq 0} B_j r_{t-j} \quad \forall t$$

where A_j and B_j are matrices of estimated structural coefficients. Repeated substitution of relations (18) and (19) for expected prices in relations (15) and (16), under the assumption that prices dated beyond the current period are expectations, produces an estimateable structural model of agriculture.

Having derived a form of the model with all variables expressed as current or lagged, the task of specifying functional forms remains. Typically, equation forms are selected arbitrarily, or general forms are utilized. In this study, the reduced form of the model is estimated

directly. This course of action is pursued because (1) there is really no way to know the functional forms of the structural equations and any presupposition is a pretension; (2) it is the reduced form of the model that is of interest since it is the mechanism which generates the time paths of the endogenous variables; and (3) if incorrect structural functional forms are assumed the results may be misspecification and the derivation of biased reduced form estimates.

The reduced form of the model is postulated as approximately linear over the sample range:[2]

$$(20) \quad y_t = d_o + \sum_{j=1}^{J} D_j y_{t-j} + D_{J+1} x_t + D_{J+2} c_t$$

where $y_t = \begin{bmatrix} q_t \\ p_t \\ z_t \\ u_t \end{bmatrix}$, $x_t = \begin{bmatrix} m_t \\ b_t \\ r_t \\ E(r_t) \end{bmatrix}$, $c_t = \begin{bmatrix} f_t \\ w_t \\ q_t \\ l_t \end{bmatrix}$,

y_t is a vector of endogenous variables, x_t is a vector of exogenous variables; c_t is a vector of control variables, d_o is a vector of intercepts, and the D_j are matrices of structural coefficients. The vector e_t has zero expected value, constant variance associated with each of its elements, and represents weather variation and linear approximation error. The expectations functions for $E(p_t)$ are embodied in the structural coefficients of the lag operators, while expected input prices are included in the x_t vector directly.

Four product markets are included in the model. These consist of (1) meats (cattle and hogs), (2) dairy products (fluid and manufacturing grade milk, and other dairy products), (3) poultry-eggs and (4) crops (food grains, feed grains, oilseeds, fruits, vegetables, and fibers). The

resource markets included are (1) land (utilized for agricultural production), (2) labor (resident family and hired), and (3) capital (direct agricultural investment less depreciation). These categorizations represent a disaggregation into the basic agricultural product and resource markets, but allows the size of the model to be kept manageable by including only a limited number of markets. Only 15 equations are included--3 for each of the product markets and one representing each resource market.

5. Estimation Results

Before the complete model can be estimated, measures of expected prices must be obtained. This is accomplished by estimating the expectations functions of the model as third-order autoregressive processes using ordinary least squares (OLS). The resulting equations, which are presented in table 1, are all stable. The land price equation (r_d) and the wage rate equation (r_1) forecast fairly well. The meat price equation (p_m), the crop price equation (p_c), the dairy products price equation (p_d), and the interest rate equation (r_k) forecast poorly. The poultry price equation (p_p) performs moderately well, however.

Following estimation, the expectations functions were utilized to forecast price time series over the sample period 1947 to 1975. The resulting values, which serve as price expectations in the model, were then included in the data matrix for equation (20) and the entire reduced form of the model was estimated using OLS. The results, after removing variables which were not statistically significant at the 10 percent level or higher, are presented in table 2. Definitions of variables included in the model are given in table 3. Prices and values are deflated using the

Table 1. Expectations Functions[1]

Variable	Estimate	R^2
p_{mt}	$\underset{(17.4)}{32.4} + \underset{(.185)}{.731}\, p_{m,t-1} - \underset{(.245)}{.226}\, p_{m,t-2} + \underset{(.215)}{.192}\, p_{m,t-3}$	.526
p_{ct}	$\underset{(10.8)}{22.7} + \underset{(.21)}{1.25}\, p_{c,t-1} - \underset{(.331)}{.941}\, p_{c,t-2} + \underset{(.207)}{.488}\, p_{c,t-3}$	.791
p_{dt}	$\underset{(10.0)}{24.1} + \underset{(.202)}{.748}\, p_{d,t-1} - \underset{(.226)}{.059}\, p_{d,t-2} + \underset{(.162)}{.069}\, p_{d,t-3}$	.725
p_{pt}	$\underset{(9.5)}{15.9} + \underset{(.198)}{.235}\, p_{p,t-1} + \underset{(.184)}{.358}\, p_{p,t-2} + \underset{(.186)}{.237}\, p_{p,t-3}$	.900
r_{dt}	$\underset{(2.87)}{-1.63} + \underset{(.21)}{1.38}\, r_{d,t-1} - \underset{(.422)}{.664}\, r_{d,t-2} + \underset{(.290)}{.340}\, r_{d,t-3}$	.980
r_{lt}	$\underset{(2.66)}{1.54} + \underset{(.17)}{1.41}\, r_{l,t-1} - \underset{(.291)}{.319}\, r_{l,t-2} - \underset{(.183)}{.102}\, r_{l,t-3}$	.986
r_{kt}	$\underset{(12.9)}{37.9} + \underset{(.128)}{.706}\, r_{k,t-1} - \underset{(.145)}{.587}\, r_{k,t-2} + \underset{(.117)}{.378}\, r_{k,t-3}$	.565

[1]Standard errors are included in parentheses.

Table 2. Reduced Form Estimates

Endogenous variable	Coefficient of: Intercept	$q_{m,t-1}$	$q_{c,t-1}$	$q_{d,t-1}$	$q_{p,t-1}$	m_t	w_t
p_{mt}	-787 (219)	-2.68 (.65)		6.06 (1.71)	3.32 (.86)		.0148 (.0043)
p_{ct}	257 (59)		2.31 (1.19)	-2.85 (.79)	-1.84 (.62)	1.30 (.72)	-.0208 (.0057)
p_{dt}	52.4 (29.9)	-.811 (.375)					.0114 (.0037)
p_{pt}	626 (383)	3.69 (1.22)		-5.46 (3.06)	-4.94 (1.69)	3.64 (1.38)	
q_{mt}	39.7 (10.5)						
q_{ct}	36.1 (7.8)		.602 (.074)	-.231 (.077)	.211 (.058)		
q_{dt}	101 (4)					.204 (.032)	.000789 (.000321)
q_{pt}	136 (10)	-.248 (.096)					.00648 (.00109)
z_{mt}	470 (73)			-2.43 (.42)	-1.16 (.36)		.00904 (.00196)
z_{ct}	-116 (37)	.663 (.219)		2.01 (.41)			
z_{dt}	81.8 (6.6)		.318 (.119)	.368 (.095)	-.216 (.074)		-.00221 (.00066)
z_{pt}	115 (40)	-.324 (.102)	1.06 (.27)	-.479 (.281)			.00371 (.00211)
u_{dt}	180 (13)			-.794 (.121)			-.000967 (.000443)
u_{lt}	170 (13)					-1.18 (.09)	
u_{kt}	-606 (160)	1.75 (.58)		3.36 (1.37)	2.79 (.76)	-1.37 (.73)	

Table 2. Continued

Coefficient of						
f_{dt}	l_{dt}	g_{ct}	g_{dt}	g_t	v_{mt}	v_{ct}
.213 (.107)	.279 (.046)		-.204 (.079)	59.9 (6.7)		
		-.392 (.077)	-.0805 (.0485)	13.8 (7.2)		.228 (.121)
-.135 (.073)		.208 (.059)	.117 (.065)	28.3 (6.1)	-.136 (.075)	
-.528 (.194)			.285 (.140)	60.9 (12.4)		-.815 (.267)
.0369 (.0145)	-.0501 (.0196)	.0625 (.0296)		-12.6 (3.0)		.0973 (.0483)
		.0135 (.0046)				.0287 (.0092)
			.00692 (.00363)			
	-.0529 (.0126)	.147 (.021)		-3.08 (1.25)		
-.0905 (.0305)	-.098 (.025)	.219 (.046)	.103 (.025)	-4.22 (1.61)		
.0995 (.0446)	-.0823 (.0163)		-.118 (.038)		.314 (.059)	
.0693 (.0099)		-.0385 (.0091)	-.0576 (.0087)	-4.44 (.82)		.0698 (.0142)
	-.0803 (.0195)	.194 (.037)		-6.90 (2.32)		.119 (.036)
	.0849 (.0183)	-.201 (.022)		7.22 (2.13)		
				78.7 (9.3)	-.405 (.099)	

Table 2. Continued

Coefficient of					
b_{mt}	$E(p_{mt})$	$E(p_{ct})$	$E(p_{dt})$	$E(p_{pt})$	$E(r_{dt})$
				1.66 (.34)	
.400 (.135)	-.519 (.219)	.663 (.145)			-.809 (.223)
-.186 (.066)		.368 (.117)			
	1.17 (.34)		2.40 (.80)	-1.11 (.59)	
.0942 (.0453)	-.151 (.067)	.186 (.063)	-.361 (.082)		-.308 (.091)
		-.0207 (.0126)	-.0463 (.0259)		.104 (.019)
	-.0631 (.0157)		-.0891 (.0305)	-.0582 (.0137)	
			-.187 (.094)	-.190 (.035)	-.0927 (.0448)
	.332 (.045)		-.74 (.12)	-.597 (.117)	
.314 (.059)	- 175 (.093)		.884 (.182)		
.0723 (.0173)	-.291 (.029)	.128 (.020)			-.259 (.024)
		-.118 (.039)		-.232 (.075)	
					-.195 (.049)
	.178 (.044)			.415 (.041)	
.339 (.112)		.720 (.189)		1.16 (.23)	2.00 (.28)

Table 2. Continued

Coefficient of $E(r_{1t})$	Coefficient of $E(r_{kt})$	R^2	dw
	-.0392 (.0202)	.941	2.36
		.983	2.54
1.03 (.27)	-.0417 (.0126)	.953	2.41
-3.45 (1.63)		.983	2.71
.971 (.100)	.0309 (.0063)	.994	2.22
		.999	2.77
	.00345 (.00191)	.996	1.80
.261 (.151)		.995	2.77
.789 (.199)		.994	1.75
-1.41 (.30)		.980	2.06
	.0227 (.0020)	.995	2.16
-.284 (.141)		.998	2.41
.184 (.051)		.929	2.09
	-.0170 (.0066)	.998	2.26
-3.39 (.49)	-.105 (.019)	.966	2.14

Table 3. Definitions of Variables

Variable	Definition
	—Endogenous Variables—
p_m	Prices received by farmers for meats
p_c	Prices received by farmers for crops
p_d	Prices received by farmers for dairy products
p_p	Prices received by farmers for poultry-eggs
q_m	Meats consumption
q_c	Crops consumption
q_d	Dairy products consumption
q_p	Poultry-eggs consumption
z_m	Meats production
z_c	Crops production
z_d	Dairy products production
z_p	Poultry-eggs production
u_d	Land used for production
u_l	Farm labor force
u_k	Net farm investment
	—Exogenous variables—
m	Personal consumption expenditures on food
w	Government food stamp subsidy
f_d	Domestic donations of dairy products
l_d	Cropland area withheld from production
g_c	Government net removals of crops.
g_d	Government net removals of dairy products

Table 3. Continued

Variable	Definition
g	Government price freeze and export embargo
v_m	Exports of meats
v_c	Exports of crops
b_m	Imports of meats

Consumer Price Index, and all variables (except one binary variable) are expressed as indices (1967=100). This facilitates the interpretation of estimated coefficients and dynamic multipliers of the model.

The results generally imply that (1) habit persistence plays an important role in the model, especially with regard to the determination of agricultural prices and production; (2) changes in food expenditures do not play a particularly important role in the model—food expenditures are statistically significant in only 5 equations; (3) government controls are important—most of the included control variables are highly significant statistically, although their impact magnitudes are not large in general; (4) trade in meats and crops has important effects on domestic agriculture; and (5) expected product and resource prices play a major role in the model.

6. Causality Tests

An underlying assumption of any model specification is that the endogenous variables are dependent on exogenous variables—causality is unidirectional from the latter to the former. If causality is not properly represented in the model, then the parameter estimates are measures of multiple correlation and not of causal structure. Rausser and Stonehouse (24) have recently suggested that much of the research on agricultural supply response provides an inadequate foundation for policy analysis for this reason—causality is not properly represented appropriately in most models because policy variables are really endogenous.

Since policy variables play a major role in the structure of the model discussed in this paper, it becomes important to test for causality. Rausser and Stonehouse propose no specific tests for causality, but simply

assume that policy variables are endogenous and develop their model accordingly. There does exist a substantial literature on testing for causality, however (see Pierce and Haugh (23) for a survey). Although no conclusions have been reached concerning the best methods for causality testing, the attention devoted to the subject suggests that some of the proposed tests at least be considered in model construction.

Granger (11) and Sims (31) outlined the statistical theory which can be utilized to test for exogeneity. This theory has recently been applied by Sargent (27) to test the specification of a macroeconometric model. Comments on Sargent's application were made by Nelson (21), with a response by Sargent (28). In his application, Sargent utilizes the concept of Granger causality to propose a least squares test and follows Sims in applying a double-sided distributed lag test. A major problem with both of these procedures is that they are tests for univariate causality--a generalized test for multivariate causality has not yet been proposed in the literature. Even so, the implications of the univariate tests may be of interest for this study.

In Granger's sense, a variable y_t is caused by x_t if y_t can be better predicted using past information on x_t than if no information on x_t is used. This leads to the specification

(21) $y_t = \sum_{i>0} \alpha_i x_{t-i} + \sum_{j\geq 0} \beta_j y_{t-j} \qquad \forall t$

Under the null hypothesis that x_t does not cause $y_t, \alpha_i = 0 \ \forall\ i$. This hypothesis can be tested using the F test for complete versus reduced models. If the null hypothesis is accepted than x_t is not exogenous with respect to y_t.

Sims' method for testing for causality requires the estimation of the

double-sided distributed lag

(22) $x_t = \sum_i \eta_i y_{t-i} \qquad -\infty > i > \infty \qquad \forall t$

Under the null hypothesis that x_t does not cause y_t, $\eta_i = 0 \ \forall \ i \geq 0$. This hypothesis is also tested using the F test, acceptance implying that x_t is not exogenous with respect to y_t.

Both of these tests are applied to determine whether causality is properly represented in the model. Two alternatives were evaluated in each case. First, the endogenous variables of the model were tested to determine whether they are caused by the exogenous variables of the model. Second, the exogenous variables of the model were tested to determine whether they are caused by the endogenous variables. If the model is properly specified, then the first possibility should be confirmed while the latter should be rejected.

Table 4 presents F statistics for Granger tests of the hypothesis that the exogenous variables cause the endogenous variables of the model. The F statistics are derived from a regression of the dependent variables on lagged dependent and independent variables lagged one through 3 years. The critical F values are 4.87 at the 99 percent confidence level and 3.07 at the 95 percent confidence level with (3,21) degrees of freedom. Approximately 20 percent of the resulting F statistics are statistically significant at the 95 percent confidence level, implying that the exogenous variables do not generally cause the endogenous variables in the model. The results do imply an important causal role for the food stamp program, land diversion, government crop removals, and the 1973 government price freeze and embargo, however.

Table 5 presents F statistics for Granger tests of the hypothesis that

Table 4. F Statistics for Granger Causality: Tests for Endogeneity

Dependent variable	Independent Variable								
	w	f_d	l_d	g_c	g_d	g	v_m	v_c	b_m
p_m	5.45	3.24	3.36	2.99	.62	11.65	.64	.32	.48
p_c	14.11	.34	.55	.26	.44	1.19	.08	1.41	.29
p_d	1.39	.71	.28	.51	.99	.48	7.03	1.69	.72
p_p	6.12	.86	.49	.71	1.07	.75	2.91	1.15	.93
q_m	3.26	.79	5.09	6.67	.71	3.84	2.41	.84	2.19
q_c	4.17	.66	4.04	3.37	1.14	10.03	4.08	5.82	.16
q_d	.05	2.22	.38	.86	2.58	.79	1.53	1.27	.24
q_p	3.39	.98	1.38	2.51	.73	.79	1.73	.02	.48
z_m	1.64	.69	4.83	5.92	.48	5.50	4.06	2.01	6.05
z_c	3.01	.18	1.22	2.95	.41	3.23	.16	.57	1.44
z_d	1.57	1.76	1.59	.95	1.37	1.15	.82	.32	3.08
z_p	3.16	2.57	1.87	1.85	2.36	1.93	.80	.43	.15
u_d	.43	1.57	2.43	.31	1.15	.45	2.54	.19	.21
u_l	5.54	.60	1.54	3.26	.91	2.28	2.68	2.20	2.73
u_k	1.28	1.19	2.12	2.35	.71	1.52	1.53	3.79	1.67

Table 5. F Statistics for Granger Causality: Tests for Exogeneity

Independent variable	Dependent Variable								
	w	f_d	l_d	g_c	g_d	g	v_m	v_c	b_m
p_m	1.10	2.36	4.44	3.90	3.33	.61	1.35	.07	.14
p_c	2.34	1.65	.96	.98	.74	1.03	4.53	1.53	3.43
p_d	.20	1.81	.99	.63	.56	.11	1.58	1.54	.20
p_p	1.21	1.39	.80	.51	.17	.68	2.23	1.23	2.34
q_m	1.86	1.48	2.41	2.53	1.14	1.96	5.03	2.49	1.31
q_c	2.06	.83	1.31	.64	.24	1.83	7.75	3.21	1.64
q_d	1.01	.11	.16	.36	.06	1.12	4.42	1.13	1.52
q_p	2.41	.61	.36	.02	.43	1.11	4.60	1.66	2.28
z_m	1.67	.05	3.06	1.24	.12	1.53	6.33	1.61	.34
z_c	4.18	.24	2.72	1.19	.49	4.32	4.68	4.57	.21
z_d	1.29	1.23	1.64	1.95	1.10	.45	1.36	2.04	2.19
z_p	2.67	.08	.75	.15	.13	1.36	3.78	1.79	3.83
u_d	1.09	.77	.68	1.17	.80	1.29	2.53	1.74	2.56
u_l	.57	1.08	1.56	.28	.82	.27	1.96	.69	1.07
u_k	2.71	.33	1.39	1.52	.63	1.29	.96	.88	.75

the endogenous variables of the model cause the exogenous variables. Only about 12 percent of the F statistics are statistically significant at the 95 percent confidence level, indicating that the flow of causality is not generally from the endogenous variables to the exogenous variables. Some evidence exists indicating that prices, consumption, and production cause meat imports, however.

Table 6 summarizes the F statistics necessary to test the hypotheses that the exogenous variables do not cause the endogenous variables using the Sims' test. The F statistics are derived from a regression of the exogenous variables on future values of the endogenous variables (one through 3 years ahead), current endogenous values, and endogenous values lagged one through 3 years. The critical F values are 4.94 at the 99 percent confidence level and 3.10 at the 95 percent confidence level with (3,20) degrees of freedom. The F statistics necessary to test the hypothesis that the endogenous variables do not cause the exogenous variables are presented in Table 7.

Utilizing the Sims procedure to test whether the exogenous variables cause the endogenous variables yields results which are not generally consistent with the findings obtained using the Granger test. About 23 percent of the test statistics are significant at the 95 percent confidence level (approximately the same number as with the Granger test), but the set of exogenous variables found to cause the endogenous variables is fundamentally different from the causal set identified using the Granger test.

Applying the Sims' procedure to test the possibility that the endogenous variables cause the exogenous variables also produces results

Table 6. F Statistics for Sims Causality: Tests for Endogeneity

Independent variable	Dependent Variable								
	w	f_d	l_d	g_c	g_d	g	v_m	v_c	b_m
p_m	.43	.18	1.15	1.99	.52	1.40	.46	.61	.59
p_c	3.23	.51	.73	.13	.93	2.78	.63	.37	.38
p_d	7.97	1.99	1.12	1.62	3.70	2.06	5.97	21.62	9.88
p_p	2.16	1.10	1.08	1.12	20.00	.86	1.37	2.36	2.70
q_m	.61	.24	.41	.20	.27	3.60	.14	.96	1.41
q_c	6.04	.85	2.66	1.66	1.54	8.60	2.71	2.59	.03
q_d	4.31	3.76	3.18	3.13	2.21	1.42	3.13	1.71	.37
q_p	1.45	.19	20.00	2.91	20.00	.60	.13	.13	.31
z_m	2.23	.57	4.52	9.52	.16	3.21	4.61	.50	5.58
z_c	.07	.15	.22	.31	.27	1.11	1.56	.07	.79
z_d	1.01	.22	2.09	1.65	.37	4.19	1.16	.68	.42
z_p	3.18	2.30	2.46	1.77	3.97	3.70	.64	.93	1.08
u_d	.17	2.66	1.38	2.69	1.50	1.44	1.46	2.39	8.03
u_l	.96	1.61	1.40	.48	1.78	.86	.18	.34	.38
u_k	5.20	2.48	2.62	3.53	1.00	1.72	4.52	8.77	9.05

Table 7. F Statistics for Sims Causality: Tests for Exogeneity

Dependent variable	Independent Variable								
	w	f_d	l_d	g_c	g_d	g	v_m	v_c	b_m
p_m	.10	2.17	5.09	2.91	1.80	.21	.26	.69	1.18
p_c	1.94	.63	.63	.50	.34	2.87	5.48	4.60	1.17
p_d	.10	2.50	1.98	1.01	.81	.23	.48	1.53	1.36
p_p	1.26	.24	.36	1.16	.83	1.91	.74	2.69	3.18
q_m	3.87	1.30	.18	2.09	2.57	4.15	2.51	8.57	2.19
q_c	3.61	1.20	.66	3.19	2.48	4.31	3.78	14.87	3.72
q_d	1.22	.42	.24	2.90	1.43	1.75	1.16	1.82	1.83
q_p	3.51	.64	.42	1.07	1.93	4.24	3.18	8.04	4.83
z_m	4.38	.86	.61	1.55	1.94	4.50	4.87	9.15	1.14
z_c	2.01	1.64	.81	3.23	2.77	5.05	2.32	3.90	1.48
z_d	.13	1.07	1.16	1.72	.43	.40	.33	1.19	1.80
z_p	3.08	.99	.50	2.86	2.76	3.55	3.25	9.33	14.42
u_d	1.54	.52	1.07	5.42	2.06	1.05	1.26	.67	.65
u_l	2.52	.71	.09	3.62	2.00	2.48	1.86	3.83	8.51
u_k	.45	3.20	1.59	.12	3.63	.28	1.04	2.82	2.48

which differ substantially from those obtained by applying the Granger test. Almost 25 percent of the F statistics are significant at the 95 percent confidence level, compared with 12 percent for the Granger test. The evidence suggests that the endogenous variables of the model cause the government price freeze and embargo, meat and crop exports, and meat imports.

The Granger test indicates unidirectional causality in 35 cases; causality in both directions in 7 cases; and no association in 93 cases. The Sims test implies unidirectional causality in 55 cases; causality in both directions in 7 cases; and no association in 73 cases. In only 22 cases do both tests imply unidirectional causality in the same direction for the same variable pairs, and of these only 13 cases are consistent with the causality direction assumed in the model.

In brief, the results of testing for causality suggest that causal flows are not properly represented in the model--the general implications are that there is little causal association among the endogenous and exogenous variables in the model. It is important to note that these results are (1) based on a univariate analysis and (2) suggest no alternative model specification. For these reasons, and because the results of implementing both the Granger and Sims test are largely contradictory, it is not clear how serious these results should be taken.

7. Model Validation

Typically, econometric models are validated over both the sample period on which estimation is based, and over a sample period outside of the estimation period. This convention is followed here--a "within sample" validation is performed using actual exogenous data over the period 1947

through 1975, and an additional validation is performed using exogenous data from the years 1976 through 1978. For both validations, actual values of lagged endogenous variables are used as seeds for deterministic simulations of the model. Generated values of endogenous variables are then used as the values of lagged endogenous variables in later periods allowing full dynamic response—simulated deterministic time paths for the endogenous variables result.

Table 8 presents mean absolute errors and Theil (34) inequality coefficients for a comparison of the simulated deterministic time paths of the model with the actual system time paths. For the within sample validation, the simulated time paths follow the actual system time paths fairly well. Although the mean absolute errors for the price of crops, the price of poultry-eggs, and for capital investment are quite large, those associated with the other endogenous variables in the model seem acceptable. In addition, the model appears to simulate turning points quite well—13 of the 15 endogenous variables have Theil inequality coefficients less than unity in value.

For the beyond sample validation, mean absolute errors for all variables are small (with the exception of poultry price), and 9 of the 15 inequality coefficients are less than unity. Some of the 1978 data are preliminary, however. Even so, the model as a whole seems to perform reasonably well. This statement is supported when the relative variability of the endogenous time paths of the model are considered. Agricultural prices and production are far more variable than prices and production in other sectors of the economy. And, consequently, are more difficult to model.

Table 8. Summary Validation Statistics

Variable	Within Sample Range: Mean Absolute Error	Within Sample Range: Theil Inequality Coefficient	Beyond Sample Range: Mean Absolute Error	Beyond Sample Range: Theil Inequality Coefficient
p_m	.051	.654	.051	.680
p_c	.220	.490	.054	.749
p_d	.053	.600	.031	.374
p_p	.345	.965	.219	1.292
q_m	.027	.563	.013	.714
q_c	.054	.328	.005	.406
q_d	.021	.435	.003	.556
q_p	.078	.571	.032	11.964
z_m	.061	1.308	.137	6.131
z_c	.030	.945	.108	9.753
z_d	.025	1.139	.043	1.923
z_p	.120	.803	.023	.208
u_d	.112	.376	.018	.457
u_1	.009	.792	.023	1.258
u_k	.232	.277	.135	.947

8. Policy Effects

Six government control variables are represented in the model. These include (1) food stamp payments, (2) domestic donations of dairy products, (3) cropland area withheld from production, (4) net market removals of crops, (5) net market removals of dairy products, and (6) a binary variable representing special policies implemented in 1973. The inclusion of these policy variables is based on the theoretics underlying the model specification, with the exception of the binary variable representing special 1973 policies--the number and diversity of policies implemented that year make quantification difficult.

Included policy variables represent the 2 major agricultural supply control programs implemented over the sample period: (1) the crop price support and land diversion program, and (2) the dairy price support program. In addition, 2 other control programs are also represented: the special 1973 policies, and the food stamp program. The effects of these programs are assessed through policy simulations and the analysis of the dynamic multipliers of the model.

8.1 Nature of Implemented Policies

Crop price supports and land diversions were designed primarily (1) to increase income for agricultural producers, (2) to stabilize prices, and (3) to provide a stable food supply to consumers. The basic instruments for accomplishing these objectives included the direct purchase of crops by the government, with mandated land diversions or acreage withholdings. The use of both of these policies result in higher prices in the short-run by reducing the market supply of agricultural products.

8.11 Crop Removals

Six basic crops were purchased by the government over the sample period: cotton, peanuts, rice, tobacco, corn, and wheat. Other nonbasic commodities were also purchased: feed grains other than corn, oilseeds, and sugar. Purchase levels varied over time, however--in some years large quantities of all of these crops were purchased, while in other years virtually no purchases were made.

Crop removals were not made directly but through loan programs. Generally, when market prices were below specified levels, commodity producers were eligible for loans with their crops serving as collateral. If market prices remained below support levels, then producers could default, receive the support price, and the government took possession of the crop. "Net removals" represent the total quantity of crop removed from the market and not resold by the government in the same year.

Price support levels do not enter the model directly. Instead, the one-to-one correspondence between a given price support level and the net removal of a particular crop is exploited through the market equilibrium identity as an approximation of the price support mechanism. When net removals are positive, prices are actively being supported. When there are no net removals, the market price is above the support price. When net removals are negative, the government is selling commodities to reduce the market price. In the model (and in actuality), net removals are the mechanism through which the government controls prices.

The use of net removals in the model as the control variable allows several problems to be overcome. It eliminates the need to calculate "effective" support prices, which has been the approach utilized in some

studies (see Houck (15), for example). In addition, it eliminates the need to incorporate an inequality stating that price is greater than or equal to the support price as some authors have proposed.

8.12 Land-Use Control

Land-use control, the other major policy used to impact crop prices over the study period, was implemented through the Cropland Conversion Program, the Cropland Adjustment Program, and other conservation programs. Land use was also restricted through set-asides and diversions associated with price support programs.

Participation incentives were made generally through (1) direct payments, up to a limit, and (2) by requiring that a percentage of cropland be diverted for producers to be eligible for price support. In both cases, a direct financial incentive was utilized to control the behavior of producers. By varying the incentive, the quantity of land diverted was varied. This one-to-one correspondence between incentive and the quantity of land diverted allows the latter to represent the appropriate control instrument in the model.

8.13 Dairy Price Support Program

The dairy product price support program was designed initially to support the income of milk producers and to provide "orderly marketing" of dairy products. To accomplish this objective, the government supported the price of dairy products (cheese, butter, and nonfat dry milk) through direct purchases. This resulted in higher milk prices at the farm level. Support prices for milk and dairy products were announced publicly and policy was implemented through the actual purchase of dairy products on the market. As with crops, the monotonic relationship between price supports

and net removals of dairy products allows net removals to be used as the relevant policy instrument in the model.[4]

Following removal of dairy products from the market, the government has been faced with a disposition problem. If dairy products were simply resold on the market, then there would be little effective price support (although prices might be smoothed over time). As an alternative, most dairy products have been donated for use under the School Lunch Program, donated under the Nutrition Program for the Elderly, and given to states for distribution to the needy and to individuals receiving public assistance.

The nature of product dispositions under price support programs has important implications for program effectiveness. Once dairy products are removed from the market, supply decreases--causing higher prices in the short-run. When dairy products are donated domestically, demand decreases since individuals receive goods through nonmarket channels. This leads to lower prices. The nature of dispositions then is crucial in determining the ultimate effects of government price support programs. The demand side effect could actually offset the supply side effect of a support program.

8.14 Policies in 1973

The most important special policy implemented in 1973 was the imposition of a ceiling on retail prices for red meat (from March through September) and a freeze on all retail food prices in June and July. Raw agricultural product markets were exempt but obviously affected since food manufacturers' and distributors' derived demands were changed drastically. Other policies applied in 1973 included an export embargo on soybeans, cottonseed, and related products during the summer; a suspension of meat

Theoretically, the food stamp subsidy should increase the demand for food. This is an implication of the argument underlying the model developed in this study and has been outlined by Sullivan (33). The interesting empirical questions relating to the Food Stamp Program concern how much the program has increased the demand for food, and whether, through demand-side effects, the program has had a substantial impact on food production.

8.2 Simulations

Seven deterministic policy simulations were performed to evaluate the effects of government programs on agricultural prices, consumption, production, and input utilization over the study period. In each simulation, the basic objective was to determine the effects on the system if a particular policy or group of policies <u>had not been implemented</u>. The results allow a determination of how well government programs satisfied their design goals.

Considered specifically were the effects of (1) the crop price support program, (2) land diversion programs, (3) the joint effects of the crop price support and land diversion programs, (4) the dairy price support program, (5) domestic donations of dairy products, (6) the 1973 price freeze and export embargo, and (7) the joint effects of all these programs. In each simulation, the values of the appropriate government policy variables were set equal to zero and deterministic time paths of the model produced. Comparative policy analyses were then performed by contrasting the distribution statistics of the simulated endogenous series (with error terms suppressed) with distribution statistics from a deterministic solution of the model. In addition, simulated values for farm income and

the farm value of domestic food consumption were computed and contrasted with their deterministic values.

A particular problem with the use of linear policy simulation is that as values of exogenous variables are changed from their original paths, the estimated model is imposed on new exogenous data which were not considered in the model construction. The consequences may be perverse simulation results when the change is substantial. In addition, a linear structure may be imposed on exogenous data reflecting nonlinear realities--the linear model is a valid representation only over the range of exogenous data used in estimation. Since there were at least several years during which each policy variable was set at zero over the study period, the substitution of zero value time paths for control variables should not lead to perverse simlation results -- the exogenous time paths are not altered drastically.

In the first simulation, the value of government net removals of crops was set to zero and deterministic time paths of the model produced. The results, in terms of endogenous variable means and standard deviations are compared to the same statistics with government net removals of crops set at their actual levels in table 9. Indications are that crop price support caused higher meat prices, and lower prices for crops, dairy products, and poultry-eggs. In addition, meat and poultry-eggs consumption were stimulated, but crops and dairy products consumption were depressed. Production of all products increased, with the exception of meats, and resource utilization was reduced.

With no crop price support, indications are that farm income would have been 14 percent lower--$1156 billion versus $1347 billion over the sample

Table 9. Selected Simulation Results: Means and Standard Deviations of Endogenous Variables Under Alternative Policies

Variable	Deterministic Model Solution	Crop Price Support	Land Diversion	Crop Price Support and Land Diversion
		--1967=100--		
p_{mt}	108.9 (17.3)	95.8 (22.0)	65.7 (40.1)	52.6 (50.1)
p_{ct}	144.7 (15.3)	212.8 (52.5)	135.4 (20.2)	203.6 (41.2)
p_{dt}	108.3 9.3)	111.6 (12.9)	98.8 (13.9)	102.2 (13.6)
p_{pt}	183.9 (31.3)	244.6 (48.9)	140.3 (67.8)	200.9 (32.5)
q_{mt}	90.3 (15.7)	67.8 (2.3)	99.3 (22.2)	106.4 (28.4)
q_{ct}	86.2 (11.3)	99.4 (22.2)	90.0 (14.0)	78.5 (4.5)
q_{dt}	93.9 (6.1)	111.6 (4.6)	98.0 (9.9)	96.1 (7.9)
q_{pt}	79.0 (8.9)	42.0 (6.5)	87.7 (16.5)	70.9 (3.0)
z_{mt}	85.1 (10.8)	97.5 (7.2)	86.8 (12.4)	69.5 (5.5)
z_{ct}	94.5 (11.6)	75.7 (16.5)	112.8 (25.3)	117.7 (29.7)
z_{dt}	100.8 (4.4)	91.9 (11.7)	108.8 (9.9)	119.6 (18.4)
z_{pt}	71.6 (14.1)	62.2 (13.1)	80.9 (22.3)	51.3 (6.5)
u_{dt}	150.3 (34.2)	174.8 (14.9)	126.7 (54.4)	151.3 (33.4)
u_{lt}	98.7 (2.0)	99.5 (1.4)	97.2 (3.5)	98.0 (2.7)
u_{kt}	104.0 (24.0)	150.8 (66.3)	114.5 (28.5)	161.4 (28.5)

Table 9. Continued

Variable	Dairy Price Support	Dairy Product Donations	Price Freeze and Export Embargo	No Government Intervention
		--1967=100--		
p_{mt}	137.4 (25.5)	161.5 (47.9)	103.6 (17.6)	75.7 (33.4)
p_{ct}	181.4 (27.4)	221.1 (56.3)	144.6 (15.9)	240.2 (67.5)
p_{dt}	121.6 (12.7)	145.0 (20.9)	106.6 (9.7)	113.9 (10.3)
p_{pt}	248.7 (37.9)	347.8 (96.8)	179.2 (34.8)	260.9 (49.8)
q_{mt}	86.3 (14.0)	83.4 (12.9)	91.6 (17.6)	103.7 (28.1)
q_{ct}	82.6 (7.4)	75.0 (1.7)	86.3 (11.5)	74.9 (2.1)
q_{dt}	88.7 (2.7)	82.7 (3.9)	94.2 (6.6)	91.2 (4.5)
q_{pt}	69.4 (2.9)	52.9 (12.9)	79.4 (9.6)	61.8 (7.6)
z_{mt}	77.1 (5.3)	67.3 (6.3)	85.6 (11.7)	62.1 (9.8)
z_{ct}	90.1 (7.4)	78.8 (5.4)	94.8 (12.7)	113.6 (25.5)
z_{dt}	97.7 (4.1)	91.0 (4.9)	101.7 (5.0)	117.3 (16.5)
z_{mt}	59.9 (4.6)	40.7 (13.4)	71.9 (14.6)	40.0 (16.1)
u_{dt}	172.1 (16.7)	204.7 (14.6)	148.9 (36.1)	171.7 (18.0)
u_{lt}	100.4 (0.9)	101.1 (1.9)	98.8 (2.0)	99.8 (1.5)
u_{kt}	128.9 (43.7)	166.8 (70.0)	102.0 (22.7)	184.3 (87.2)

period (compare rows 1 and 2 of table 10). The crop price support program also resulted in a higher value of domestic food consumption— $1175 billion versus $980 without the program. Hence, the simulation results suggest that government price support for crops increased farm income but also contributed to higher consumer food prices as increased farm prices were passed through to the retail level.

In the second simulation, the value of the land diversion variable was set equal to zero. The results (presented in table 9) suggest that the land diversion programs stimulated higher prices for all agricultural products, led to lower per capita consumption, resulted in decreased production, stimulated land and labor utilization, but depressed capital investment in agriculture. In addition, indications are that land diversion programs resulted in lower farm income, $1538 billion without diversion as opposed to $1347 billion with diversion, and led to a lower value for domestic food consumption, $1333 billion without diversion versus $1175 billion with diversion. These findings support a perspective of diversion programs as a cause of higher agricultural prices, while failing to increase farm income—revenue declines from decreased production more than offset revenue increases from higher prices.

The first 2 simulations considered separately policy programs which have been implemented jointly over much of the sample period—eligibility for price support has been conditioned on participation in set-aside programs in recent years. Obviously, there is an association between net crop removals and land diversions. A third simulation was performed to examine this association. In this simulation the values of government net removals of crops and land diversions were set equal to zero over the sample period.

Table 10. Selected Simulation Results: Farm Income and the Farm Value of Domestic Food Consumption Under Alternative Policies

Policy	Farm Income			Farm Value of Domestic Food Consumption		
	Total	Mean	Standard Deviation	Total	Mean	Standard Deviation
	--1967 dollars in billions--					
Deterministic Model Solution	1347	48.1	1.33	1175	42.0	1.25
Crop Price Support	1156	41.3	1.24	980	35.0	1.13
Land Diversion	1538	54.9	1.43	1333	47.6	1.33
Crop Price Support and Land Diversion	1517	54.2	1.42	1143	40.8	1.23
Dairy Price Support program	1573	56.1	1.44	1394	49.7	1.36
Dairy Product Donations	1616	57.7	1.46	1528	54.6	1.42
Price Freeze and Export Embargo	1319	47.1	1.32	1159	41.4	1.23
No Government Intervention	1753	62.6	1.52	1355	48.3	1.34

The results of the third simulation indicate that crop price support and land diversion programs jointly led to higher meat prices, lower crop prices, higher dairy product prices, and lower poultry-egg prices. In addition, consumption of crops and poultry-eggs were stimulated by the programs, while consumption of meat and dairy products were not; production of crops and poultry-eggs increased, while meat and dairy products production did not; and land and capital utilization declined. With both crop price support and land diversion programs implemented, farm income was $60 billion less than it would have been without them.

In brief, with respect to the satisfaction of program objectives, it is clear that the crop price support and land diversion programs failed to increase farm income. These programs did increase price stability (as evidenced by lower standard deviations on prices and income), but also had a positive effect on food prices since the value of food consumption was increased as a result of the programs.

In the fourth simulation, the values of net government removals of dairy products and domestic dairy product donations were set to zero. This allows an evaluation of the effects of the dairy price support program. In the fifth simulation, the values of domestic dairy product donations were set to zero, but net government removals of dairy products were allowed to remain at actual historic levels. This simulation was designed to allow an evaluation of the dairy price support program if net removals had been donated for use in other countries instead of being donated for domestic use.

The results of the fourth simulation, the evaluation of the total effects of the dairy price support program, indicate that the program led

to lower prices for all agricultural products, increased consumption and production, and decreased resource utilization. The dairy price support program also resulted in reduced farm income, $1573 billion without the program versus $1347 billion with it, and a lower farm value of domestic food consumption, $1394 billion without the program compared to $1175 billion with it. The basic reasons for these results were that reduced revenue from lower prices more than offset increased revenue from increased consumption and production.

The fifth simulation, with external disposal of dairy product net removals, approximates a situation where there would be no demand-side effects on domestic markets. This would be the case under a program where, for example, dairy products were donated under PL 480.

Simulation results indicate that the effects of domestic donations largely offset the effects of the dairy price support program. If dairy products removed under the dairy price support program had been donated under PL 480 programs, agricultural product prices would have been much higher (especially dairy product prices), domestic consumption and production lower, and input utilization reduced (compare columns 5 and 6 of table 9). With external disposition, farm income would have been higher -- $1616 billion versus $1573 billion; and the value of domestic food consumption would have been greater--$1528 billion versus $1394 billion. Consequently, external disposition of dairy products would have enhanced the realization of the design goals of the program.

In the sixth simulation, the binary variable representing the 1973 price freeze and export embargo was set to zero. Results indicate that the effects of the 1973 policies were to substantially increase the prices of meat, dairy products, and poultry-eggs. In addition, the 1973 policies led

to small declines in consumption and production of agricultural products, with meat consumption declining the most (see column 7 of table 9).

Farm income was increased by the 1973 policies, and would have totaled only $1319 billion if the 1973 policies had not been implemented (versus $1347 billion with the policies). The farm value of domestic food consumption was also higher as a consequence of the 1973 policies. For this reason, the 1973 policies, while they may have held down retail food prices, actually caused higher farm food prices. This was attributable mostly to the effects of the beef price ceiling and freeze, which totally disrupted the meat marketing system. Meat producers withheld animals from slaughter and the additional revenue obtained as a result of higher prices more than compensated for declines in slaughter. Dairy producers and poultry-eggs producers benefitted from substitution effects, and the results were higher farm incomes and higher costs for food at the farm level.

The final simulation was designed to evaluate the effects of all government activity on agriculture over the sample period: the values of all 5 government control variables were set to zero and deterministic time paths generated. These time paths approximate an unrestricted free market solution and represent prices, consumption, production, and input utilization which would have occurred had there been no crop price program, no land diversion, no dairy price support program, no domestic donations of dairy products, and no 1973 price freeze and export embargo.

With no government interference, indications are that meat prices would have been lower, crop prices higher, dairy product prices higher, and poultry-eggs prices higher. Meat consumption would have been higher with no government intervention in agricultural product markets, but consumption

of crops, dairy products, and poultry-eggs would have been lower. And with no government programs land utilization would have increased, more labor would have been utilized, and capital investment would have been intensified.

Agricultural income would have been higher over the sample period with no government intervention —$1753 billion versus $1347 billion, an increase of 30 percent. In addition, the farm value of domestic food consumption would have been larger—$1355 billion, compared with $1175 billion, an increase of 15 percent. This suggests that the government programs failed to increase agricultural income, even though this was a basic objective. Consumers benefited from government agricultural programs, however, paying much less for food products than would have been the case without governmental intervention.

8.3 The Food Stamp Program

The statistical significance of the estimated coefficients associated with the food stamp program indicates an important role for this demand side policy, even though the food stamp program was important only over the last 5 years of the sample period. One approach to analyzing the effects of the food stamp program would be to set the value of the food stamp subsidy variable to zero and perform a policy simulation. However, food stamp subsidies partially determine consumer food expenditures in the first stage of the consumer decision problem. Since the empirical model generates no information on this relationship, policy simulation would not be very useful. One alternative is to compare the dynamic multipliers for these 2 variables.

Tables 11 and 12 present Goldberger (10) impact, interim, and total multipliers for unit changes in consumer food expenditures and the food

Table 11. Impact, Interim, and Total Multipliers for a Unit Increase in Food Expenditures

Variable	Lag in years									
	0	1	2	3	4	5	6	7	8	∞
p_m	.0	2.7	-.3	1.2	.8	-.7	.4	1.5	-1.1	12.9
p_c	1.3	.5	-1.1	.6	.6	.0	.7	.2	.0	15.5
p_d	.0	.6	-.5	.0	.7	-.3	.2	.3	-.1	4.9
p_p	3.6	-2.1	4.6	-2.6	1.4	2.8	-1.2	.3	3.2	32.8
q_m	.0	.3	-.6	.0	.1	-.3	.1	.0	-.3	-.4
q_c	.0	-.1	-.1	.0	-.1	-.1	.0	.0	-.1	-2.8
q_d	.2	-.1	-.2	.0	-.1	-.1	.0	-.1	-.1	-2.3
q_p	.0	-.2	-.3	.0	-.1	-.2	.0	-.2	-.1	-5.9
z_m	.0	-1.0	.1	.2	.1	-.1	.2	-.6	.6	-3.6
z_c	.0	.4	.2	-1.0	-.2	.2	-.5	.2	-.2	-3.1
z_d	.0	.3	-.7	.0	-.2	-.2	.1	.0	-.3	-1.5
z_p	.0	-.4	-.2	.1	-.4	-.1	.1	-.4	.0	-7.9
u_d	-1.1	.4	.7	.4	.5	.3	.1	.5	.3	11.7
u_l	.0	-.2	-.1	.2	.0	.0	.1	.0	.0	1.0
u_k	-1.4	2.8	.4	-2.1	2.1	-.2	-1.0	2.1	-.9	14.4

Table 12. Impact, Interim, and Total Multipliers for a Unit Increase in the Food Stamp Subsidy

Variable	Lag in years 0	1	2	3	4	5	6	7	8	∞
p_m	.015	.026	.010	.014	-.014	.004	.013	-.010	-.003	-.017
p_c	-.021	-.037	-.015	-.001	-.010	-.006	-.007	-.008	.001	-.226
p_d	.011	-.010	-.002	.005	-.002	-.004	.002	-.003	.000	-.038
p_p	.000	-.003	-.019	-.023	.026	-.032	-.015	.013	-.025	-.310
q_m	.000	-.010	-.005	.000	-.004	-.001	.000	-.003	.001	-.021
q_c	.000	.001	.002	.002	.002	.002	.001	.001	.001	.037
q_d	.001	-.001	.000	.000	.000	.001	.000	.000	.001	.019
q_p	.006	-.001	.004	.002	.002	.002	.001	.002	.003	.067
z_m	.009	-.012	.017	.001	.006	.000	.001	.005	.003	.056
z_c	.000	.007	-.019	-.004	.001	-.003	-.002	.000	-.003	.001
z_d	-.002	-.008	-.008	-.001	-.004	.001	-.002	-.003	.002	-.017
z_p	.004	.000	.009	.002	.004	.006	.002	.004	.005	.010
u_d	.000	.002	.003	-.002	-.003	-.005	.000	-.003	-.005	-.109
u_l	-.001	-.002	.002	.000	-.001	.001	.000	.000	.000	-.009
u_k	.000	.002	-.046	-.001	-.011	-.024	.006	-.013	-.016	-.214

stamp subsidy. Indications are that increases in real food expenditures have immediate positive impacts on crops and poultry-eggs prices, and positive effects on meats and dairy product prices after one year. In subsequent years, the effects of increased real consumer food expenditures continue to be substantial, cycling with only limited convergence after 8 years. The total effects over an infinite horizon indicate that a one unit increase in real consumer food expenditures eventually results in a 12.9 percent increase in meat prices, a 15.5 percent increase in crops prices, a 4.9 percent increase in dairy product prices, and a 32.8 percent increase in poultry-egg prices.

A unit increase in the food stamp subsidy leads immediately to higher prices for meats, dairy products, and poultry-eggs, but lower crops prices. In addition, consumption of all products is stimulated. After one year, the interim effect of a unit increase in the food stamp subsidy is higher meat prices, but lower prices for other products. In subsequent years, the price effects are cyclical and do not converge rapidly. The total effects on prices over an infinite horizon are negative.

An increase in the food stamp subsidy necessarily implies an increase in food consumption expenditures if program participants purchase more expensive foods or a greater quantity of food. This is a consequence of the way food consumption expenditures are measured, the food program structure, and the fact that food is a normal good. The unanswered question concerns the extent to which food stamp subsidies increase food consumption expenditures.

A partial response to this question is possible by reviewing changes in the food stamp subsidy and consumer food expenditures. Over the last 9 years of the sample period, the food stamp subsidy increased an average of

$.281 billion per year while total food consumption expenditures increased an average of $3.408 billion per year (both in constant 1967 dollars). These represent a 265 percent average annual increase for food stamp subsidies and a 3 percent average annual increase in food consumption expenditures.

Under the assumption that all of the food stamp subsidy was expended on food, the multipliers in table 11 and 12 imply that an average subsidy increase of $.281 billion would increase meat prices 4.0 percent, increase dairy product prices 2.9 percent, and increase poultry-eggs prices 0.9 percent. The immediate impact on crop prices would be a 5.0 percent decline, however. Most of the impact would occur after a one year interim: meat prices would increase 7.3 percent, while crops prices would decline 9.3 percent, dairy product prices would decline 2.4 percent, and poultry-eggs prices would decline 1.3 percent. After a 2 year interim the effects have the same signs but are much smaller in magnitude. After many years, the cummulative effects of an average increase in the food subsidy would be a 2.6 percent increase in meat prices and lower prices for other agricultural products.

These findings reflect a situation where the food stamp subsidy is completely expended on food, a somewhat unrealistic example. Even so, the results are intuitively plausible. As low-income individuals receive assistance, their abiliby to purchase more expensive foods is enhanced. An obvious purchase choice would be meat, one of the more expensive foods on a pound for pound basis. As a result, meat prices are bid up while the prices of other agricultural products decline —a direct response to the food stamp subsidy.

9. Limitations

The policy implications of this study are, of course, highly conditional on the model. For this reason, conclusions based on it must be qualified. Four necessary qualifications involve considerations of (1) the expectations formations process; (2) the omission of an explicit role for inventory accummulation and decummulation; (3) the inclusion of exports and imports as exogenous variables; and (4) the representation of policy decisions as exogenous when in fact policy decisions are influenced by equilibrium prices and quantities.

Regarding the expectations formation process used in this study, it must be noted that the specification is largely arbitrary. Decision makers use linear least squares price predictions, a seemingly simplistic approach. Even so, a large amount of information is conveyed through this expectations formation process--each price is caused by a large number of exogenous variables. To illustrate, consider the price support program for crops. The government announces a price support level for crops and than proceeds to make the necessary purchases in the market. In the model, this is reflected in an increase in government crop removals, which drives up the price of crops directly. Through the price expectations relationship, this results in a higher expected price in the following year, a direct consequence of policy this year. This is the type of expectations process which might be expected to occur in actuality.

The only expectations formations processes which are viable alternatives would involve the inclusion of additional lagged endogenous variables in the price autoregression, implying that decision makers were capable of a more complex understanding of market interactions. Since in some of the largest firms in the country forecasts are often made on the

basis of naive no-change extrapolations, this would appear to be going too far. Some experimentation using alternative expectations formations processes was attempted, however.[5] The results did not generally alter the basic findings of the previous section.

The omission of a role for inventorys in the model is a consequence of simplification using the underlying theoretical structure. In the long-run, stocks held by firms (or by consumers) depend on expected prices. But in the short-run, the supply of agricultural products and the derived demand for resources are dependent on stocks. Substitution of the fixed supply equation in the short-run firm supply and derived demand equations results in the elimination of inventories from the model and the dependence of supply and demand on expected prices.

The other 2 limitations of the model, the exclusion of international markets for meats and crops, and the modeling of policy formulation as an endogenous process, involve important issues considered in the literature in recent years. An explicit representation of international markets integrated with domestic markets is possible on the basis of trade theory. Regarding policy formulation, it is not yet clear how policy variables should be represented endogenously in econometric models.

Alternative specifications of the model might significantly alter the simulation and multiplier results presented in the previous section. This is not likely, however, unless an alternative specification would result in a substantial change in the list of exogenous variables included in each equation or if the endogenous feedback structure of the model was significantly changed. In addition, the results of the validation attempts indicate that the model replicates behavior in the agricultural system fairly well. On this basis, and because there is little evidence to

suggest a more comprehensive and appropriate alternative, the policy simulation results and multiplier implications seem acceptable.

10. Implications

On the basis of policy simulations and multiplier analysis, 4 major findings are apparent. These are that government programs (1) failed to increase farm income over the study period; (2) reduced the farm value of domestic food consumption, implying benefits to consumers; (3) stabilized agricultural product prices; and (4) that the food stamp program has had small effects on prices, consumption, and production of agricultural products. These findings have important implications concerning the effectiveness of government policies in agriculture.

The most important finding of this study is that government programs did not increase farm income, and in fact had a negative effect on income. This supports the argument that government programs kept small, less efficient producers in agriculture when their resources could have been more efficiently used in alternative pursuits. In addition, the evidence supports the position of economists who have argued that income distribution could be accomplished more efficiently through direct payments to agricultural producers rather than through traditional programs.

A major reason for government intervention in agriculture was to increase farm income. To the short-sighted the logic was simple: divert land to noncrop use and further reduce market supplies through direct government purchases. Then, because demand was inelastic, the revenue gain would be greater than revenue loss, increasing farm income. In reality, unplanted land was a wasted resource and government programs reduced employment and investment. In addition, demand was not inelastic but was <u>simultaneous</u> with supply over time so that the revenue effects of

government activity could not be easily discerned. Crop price support with external dispositions of government removals could have resulted in higher agricultural income. But implemented jointly with massive land diversions, the results were exactly the opposite—lower farm income and allocative inefficiency.

The second major finding of the study, that government programs reduced the price of food to consumers, is an important result which illustrates why food prices in the U. S. are the lowest among developed countries. Without government intervention, meat prices would have been lower, but the prices of crops, dairy products, and poultry-eggs would have been higher. Meat consumption would have been greater, however, but consumption of crops, dairy products, and poultry-eggs would have been lower without government programs. Lower meat costs more than offset higher costs for the other agricultural products, implying reduced food costs to consumers. In addition, implications are that government policy had a substantial effect on the diets of consumers in the U.S.—besides reducing food costs, the composition of food consumption expenditures was changed.

Regarding the price stabilizing effects of government programs, the results are striking. Government programs reduced the standard deviations of the price series by more than 60 percent for some products. This clearly is a consequence of the selective holding and release of stocks under price support programs. As government stocks increased, the disposition problem intensified, but usually was resolved by a small harvest within a few years. The net results were a smoothing of agricultural product prices over time.

A reduction in price variation as a consequence of government programs may be one of the factors contributing to lower farm incomes. Less price

variation in an industry results in greater output and larger firm numbers because of risk adversity, according to Sandmo (26). This may explain why so many marginal firms have remained in agriculture--government programs reduced price variation.

The fourth major implication of the study is that the food stamp program has had a significant but small effect on consumer food prices. Assuming constant farm to retail marketing margins, the results of the multiplier analysis imply that an average increase of $.218 billion in the food stamp subsidy would result in a 0.2 percent increase in the Consumer Price Index for food. After one year there is little additional impact on retail food prices--higher retail meat prices are offset by lower prices for crop products.

These results generally are consistent with previous studies on this issue. Belongia and Boehm (2), and Schrimper (29) conclude that food assistance programs have had a small positive effect on retail food prices. In addition, Blakely (3) concluded that food stamp subsidies have a positive effect on beef prices--further corroborating the results presented here. These conclusions would appear intuitive without an empirical analysis, however. The food stamp subsidy currently represents only about 2 percent of domestic food expenditures. Given the numerous substitution possibilities among foods, it would seem that a small effective increase in income available for food purchases would have only a small impact on prices.

11. Conclusion

The results of this study lead to a rejection of the notion that government programs increase farm income in the long-run. Dynamic analysis reveals that while government programs increased farm income during some

years of the sample period, in the most years they did not. The cumulative effects were reduced farm income -- basically as a consequence of induced resource misallocation. Land use was directly restricted, as were capital and labor utilization indirectly.

If the only objective of government intervention in agricultural product markets was to achieve income redistribution, then a more efficient method for accomplishing this goal would have been through direct income transfer. Because there have been other objectives associated with government policies in agriculture, the efficiency question must be resolved through a consideration of the total benefits and costs from government programs, not just the benefits and costs from income redistribution, however.

The findings of this study are partially corroborated in an analysis performed by Lamm (18). In that study, Lamm developed a 24 equation model of the U.S. economy with a 5 equation agricultural sector, a manufacturing-service sector, a money market, and a consumption sector. Despite differences in model specification, structure, and estimation, Lamm concludes that "the price support system may have been counter-productive by reducing agricultural income and output below that which would have otherwise obtained if there had been no government subsidies to agriculture." The results of the present study support this conclusion.

FOOTNOTES

1. Although the demand for agricultural products is in reality a derived demand, it is viewed as a consumer demand in this study to simplify the analysis.

2. This assumption, of course, may also be a pretension.

3. This step is viewed as an identification of zero value coefficients in the reduced form.

4. Milk marketing orders, which are an important part of the dairy price support program, are not considered explicitly in the model.

5. Versions of the model using $E_{t-1}(p_t) = \alpha p_{t-1}$ and $E_{t-1}(p_t) = p_{t-1}$ did not change the direction of effects, although the magnitudes were altered somewhat.

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